Creating the perfect collision

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The more the bumper and front of the car deform, the better it is for the people inside a car during a car crash. Credit: Henrik Sundgård

A good car collision should look awful. The more deformed the bumper and front end of the car are, the better. It means that these components have absorbed all of the shock from the collision, leaving the passengers inside unscathed. Damage to the exterior doesn't matter as long as the people inside the car are protected.

Getting collisions to look just like this is something the automobile industry works hard on. On their team is a group of researchers at the

Norwegian University of Science and Technology's SIMLab. The group at SIMLab works to design aluminium, steel and plastic structures that can withstand high-energy collisions and protect passengers. The group is a research-driven innovation centre financed by the Research Council of Norway and led by Professor Magnus Langseth.

"I tell people that we don't actually know that much about cars here at SIMLab," Langseth says. "We just know a lot about aluminium. That's why we work with big automobile companies like Audi, Toyota, BMW, Honda and Renault."

All innovation in the automobile industry is heavily reliant on computers, requiring accurate models of the way materials used in cars behave under stress. This is where SIMLab comes in.

Poking and prodding different materials to keep you safe

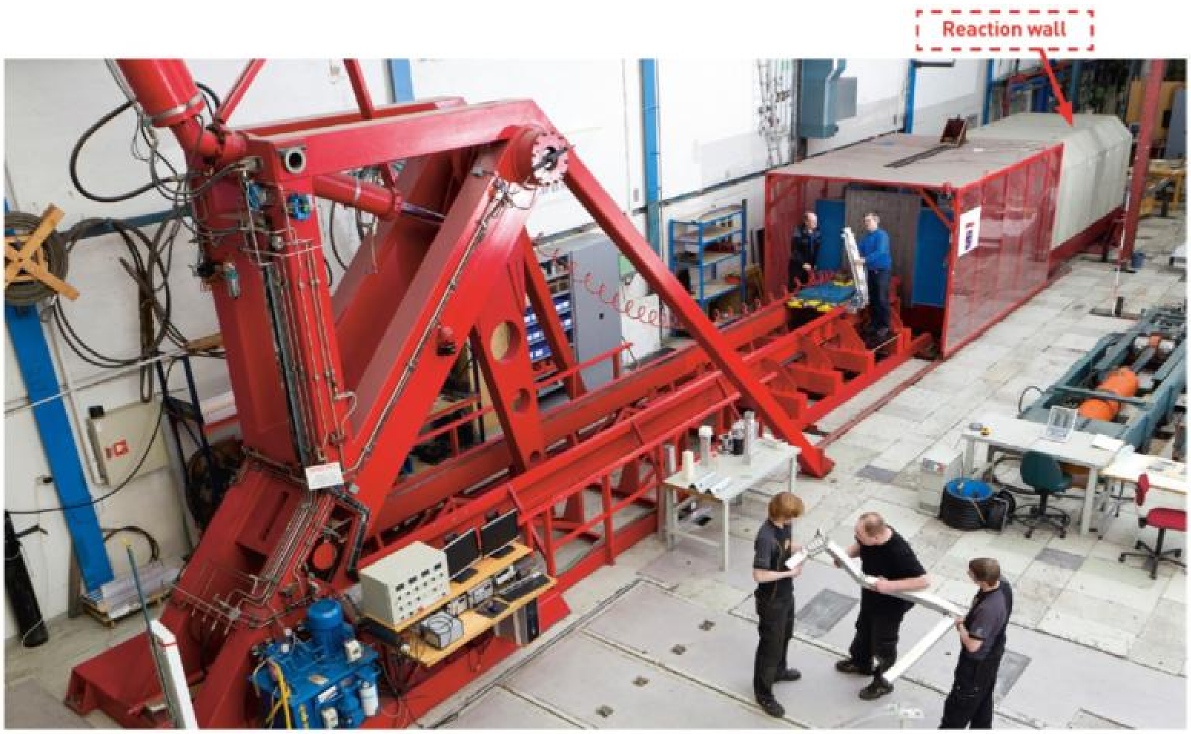
One traffic collision can involve multiple organizations that SIMLab collaborates with. The aluminium in the car's bumper may be shaped based on results from one of SIMLab's models. The bolts in a guard rail could be designed based on the way SIMLab recommends for handling stress.

"We're experts on materials, and how they work together to make a good product," Langseth explains.

He shows us a picture of a car part made of aluminium, and approximately the size of a loaf of bread.

"You could make this out of steel, plastic, or some composite material. But the most important thing is to understand how the shape affects the way the material handles stress. If it was made of a different material, it might have to be a completely different shape too, so that it will compress in the right way during a collision," Langseth explains.

Similar shapes made of different materials may have different properties, in other words.



The pendulum accelerator, otherwise known as the "kicking maching" is the largest machine of its type in the world. The kicking machine is designed to deliver high impact, high velocity blows to whatever material scientists want to test. The machine is also outfitted with a high-speed camera so researchers can conduct frame by frame analysis of what has happened during the collision. Credit: Ole Morten Melgård

"You have to optimize the material for the shape of the part you are building, which is what we use computer simulations for. You can do test after test, or turn on a computer simulation in the afternoon before you go home for the day, and come back the next morning to the finished model."

Since SIMLab was started in 2007, researchers have tested, poked and prodded all sorts of materials. It includes a practical lab where the accuracy of material simulations and different composites of materials can be tested, and where researchers can see how finished structures handle stress and strain.

"Many models require physical tests to collect enough data about the material we're replicating. But our ultimate goal is to understand the physics of problems, and provide versatile models that the industry can use," says Langseth. "For the industry, the price tag is important. The way we connect understanding the physics of a problem, making a good model that the industry can use, and testing it in the lab before it is released to the public is something unique that only we have to offer."

Material discovery

In his office, Lanseth has a number of aluminium structures of varying sizes that have been deformed and compressed into beautiful shapes on his bookshelf. He shows us two aluminium structures that look like car parts. One of them has been slowly compressed and looks like a perfect aluminium curl. The other one has been compressed rapidly, the way a car crashing into a guard rail would. It is completely deformed— no perfect curls.

A part will behave in one way when compressed slowly, and very differently in a crash. This difference is what we have to understand and include in the models that we make for the industry. It's this kind of thing you need to simulate to know how a material in a certain shape will act when compressed at a certain speed.

"We have to ask ourselves which material characteristics of this specific aluminium alloy cause this behaviour, and then adjust the alloy so it acts the way we want it to in different situations," Langseth explains.

The models made at SIMLab are based on the physics of the problem researchers are trying to solve. One of their main focuses is breakage in materials. If a car component breaks in a way that is unexpected, you have a problem, because the rest of the surrounding components begin acting differently too.

"It has to do with the way forces are transferred to the rest of a structure if a part breaks unexpectedly," Langseth says. "So we work a lot to understand how aluminum acts when it is close to breaking."

Terrorism protection on an atomic level

SIMLab's research helps save lives, which requires researchers with many different specialties to work closely together.

"Here, the people who are experts on design work with our materials experts and modelling and simulation specialists. Having all of this in one research group is pretty unique," Langseth says.

The research group has been studying aluminium for the automobile industry for eight years. Now, the Research Council of Norway has given them funds for a new research centre. There, they will work not only with the automobile industry, but also with companies that use lightweight materials in the oil and gas industry, and for terrorism prevention.

"Research is the core of innovation— you can't base new developments only on previous experience. This is why it is so important to work in connecting different industries with different areas of expertise, to see how they can learn from each other," he says.

There are as many particles in one cubic metre of aluminium as there are grains of sand on a beach. SIMLab aims to understand how structures work down to the microscopic level. And they've discovered that interactions between these particles are another thing they need to be able to understand. Therefore, they're going to the atomic level to find the best way to protect our fragile human bodies.

Provided by Norwegian University of Science and Technology

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